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JUST HOW SERIOUS IS INSIDER TRADING?

An evaluation using thoroughbred wagering markets*

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This paper quantifies the extent and changes in insider trading in the Melbourne racetrack betting market using a unique, long term dataset. Wagering markets share many of the characteristics of other financial markets, and are simple, with good data and a designated endpoint. Thus they are an excellent natural laboratory to study what is probably happening in qualitatively similar conventional markets. Results of this paper provide statistically significant support for hypotheses supporting the existence and increase in level of insider trading, and suggest that around two percent of betting is by insiders.

Classification Code: G14 - Information and Market Efficiency, D82 - Asymmetric and Private Information

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1. INTRODUCTION

The possibility of insider trading is an important concern in financial markets. Incentives promoting it are clear in the huge flows of funds, whilst the relative anonymity afforded to investors is an advantage. Stakeholder fears about the possibility of market abuses justify the power and funding given to regulators such as SEC and NYSE in the United States and ASIC and ASX in Australia. And reminders that at least some abuses occur come through the occasional prosecution, including such high profile insiders as Martha Stewart and Rene Rivkin.

Despite the apparent importance of insider trading to scholars and investors, its extent and impact are difficult to quantify because most financial markets are characterized by continuous flows of information and the lack of a clear end point. Thus analyses are typically constrained to anecdotal evidence and indirect measures.

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There is, however, one group of important financial markets where it is possible to quantify insider trading. These comprise wagering markets, where data is comprehensive and readily available. The flows of funds are large, with real money at stake: in Australia, for instance, around $US10 billion is wagered on racing each year, with $300 million going to taxes and about $1.3 billion to the operators (Tasmanian Gaming Commission, 2003). Bettors have access to a large amount of relatively cheap information; these markets are clearly competitive; and there is extensive prudential supervision of the industry (by 'the stewards' and others) to prevent manipulation of race results and returns from betting. Wagering markets have the significant advantages (for financial analysts) of being isolated from external influences, with a fixed stock of information, and a common structure around the world. Participants know payouts in advance, and each bet has a clearly defined value and end point (Brailsford, Easton, Gray and Gray, 1995). Sauer (1998) and Thaler and Ziemba (1988) give comprehensive reviews of the literature, whilst innovative contributions have been made by Busche and Walls (2000), Johnson and Bruce (2001), Levitt (2004), Schnytzer and Shilony (1995), and Vaughan Williams and Paton (1997).

Wagering markets are a wonderful natural laboratory to study the behavior of financial decision makers who face risk and uncertainty. As they share many of the characteristics of other financial markets, conclusions in relation to insider wagering point to what is probably happening in qualitatively similar financial markets where financial flows are large and supervision is strong. This has been clear since Thaler and Ziemba (1988: 161–2) commenced their series of articles on market anomalies in the *Journal of Economic Perspectives* with the observation: "Economists have given attention to stock markets in their efforts to test the concepts of market efficiency and rationality. Yet wagering markets are ... better suited ... "

Although there have been a number of studies of insider trading in wagering markets, none has used a long term dataset covering both pari-mutuel and bookmaker markets on the same races. Moreover no previous study has developed and tested a comprehensive set of hypotheses of market biases that would arise from insider activity. Thus the contribution (and innovation) of this paper is to use new data and a new analytical approach to answer two research questions: what is the extent of insider trading in wagering markets? And has this figure changed through the last decade?

Results are conclusive. Empirical measures show that insiders place just over two percent of all bets accepted by bookmakers, and about half of one percent in the much larger pari-mutuel market. Both markets are biased as expected by the presence of insiders, and their impact has increased significantly over the last decade.

The balance of the paper proceeds in four parts. Section I reviews previous studies, whilst section II introduces relevant features of wagering markets and describes the setting and data for this study. Sections III and IV, respectively, report the analytical results and discuss the findings, including broader financial implications and suggestions for further research.

2. LITERATURE REVIEW

The issue of inside or informed trading in financial markets has an understandable attraction for finance scholars. Fama (1970) promoted interest by a discussion of 'strong efficiency', which means that no investor can profit from information that is not available to the general public. Tests for market inefficiency date back to Fama, Fisher, Jensen and Roll (1969) who looked at the rate that stock prices adjust to new information (which relates to 'semi strong' efficiency) and published the classic event study.

A stimulus to analysis of strong efficiency and a challenge to the concept of efficiency in general is the inability of publicly available information to explain market moves. For instance, Fair (2002) tracked the United States S&P 500 futures contract between 1982 and 1999 to identify moves of greater than 0.75 percent within any five minutes (about seven standard deviations above average). He found 1,159 examples, and then searched newswires at that hour, but found that 90 percent of these extreme moves had no identifiable cause from outside the market.

Although the literature now displays considerable interest in the existence of strong inefficiency, virtually all evidence is obtained indirectly. In a typical example, Rafferty and Tomljanovich (2002) studied the bond market around the 1994 decision by the US Federal Reserve Board to immediately publish changes in its monetary policy. They found that the market became more efficient at predicting future interest rate movements, and thus provided less opportunity for insider profits.

Most tests of strong efficiency use event studies of market reaction around significant announcements ranging from CEO turnover (Niehaus and Roth, 1999) and grant of executive stock options (Chauvin and Shenoy, 2001) to new listings (Webb, 1999) and takeovers (Jayaraman, Frye and Sabherwal, 2001). A further set of studies has examined the extent to which some classes of investors are able to 'beat the market', with the presumption that this is at least partly due to their ability to access information that is not generally available. Possible inside investors include directors (Hillier and Marshall, 2002) and professional fund managers (Mikhail, Walther and Willis, 2004).

A large scale study of stock price changes around acquisition announcements by Bris (2005) concluded that insiders made positive returns in at least 30 percent of this sample of transactions. Cornell and Sirri (1992) obtained detailed records of trading in a takeover firm during the month before its acquisition and found insiders bought 29 percent of the stock sold. Meulbroek (1992) examined cases of insider trading detected by the Securities and Exchange Commission, and concluded that insiders were responsible for most of the abnormal trading volume prior to the market sensitive announcement, and caused about half the pre-announcement price move.

Although the general conclusion of such studies is that there is statistically significant evidence of insider trading in many financial markets, some results may be an artifact of the study methodology (Eckbo and Smith, 1998).

This makes it desirable to quantify the extent of insider trading and any change in its incidence.

The difficulties of measuring insider activity in financial markets have encouraged analysts to turn to wagering markets where investors ('bettors') who outperform the general public can be conveniently thought of as falling into two groups. One uses publicly available information, but processes it with superior skill. This could be achieved by technology, such as sophisticated analysis of comprehensive databases or intensive scrutiny of race videos. In other cases, it might be more intuitive. Such skilled bettors - 'professionals' to many people – do not invalidate strong market efficiency, and there is considerable (if largely anecdotal) evidence to suggest they are active (e.g. Kaplan, 2002).

The second group of bettors who enjoy superior financial returns make use of information that is not generally available. The sources of knowledge exploited by these true insiders are legion. For instance, owners, jockeys, trainers and industry figures with special access might become aware that a horse is to run particularly well or badly. Whatever the source of insiders' information, it is not publicly available.

Studies on Australian racetracks by Tuckwell (1983), Bird and McCrae (1987), and Schnytzer and Shilony (1995) show that insiders have been operating there for over 20 years. In fact, someone who is not knowledgeable about thoroughbred racing could be forgiven if they concluded from press reports that the industry is massively corrupt. Consider some headlines from Australian daily newspapers whilst this paper was being researched:

- Sydney vet in hot water [*The Sunday Age* 23 May 2004]
- Robinson escapes riding ban [*The Australian* 25 May 2004]
- Stewards focus on bookie's contacts [*The Australian* 29 May 2004]
- Stewards fine trainers over rule breaches [*The Australian* 19 June 2004]
- TAB tickets used to launder cash [*The Australian* 7 July 2004]
- Jockey out for six months [*The Age* 17 July 2004]
- Stewards take no action in probe over jumps jockey's call [*The Age* 24 July 2004]
- Swab sparks corruption probe [*The Australian* 30 July 2004]
- Jockey outed for betting against himself [*Sunday Age* 26 September 2004]
- [Bookmaker] Read meets stewards over 'fixing' claims [*The Australian* 23 November 2004]
- Melbourne bookie gets 12-month ban for accepting illegal phone bets [*The Australian* 22 December 2004]
- [Jockey] Nikolic under the whip at hearing [*The Australian* 6 October 2005]
- Nationwide sting hits greyhound racing [*The Age* 21 December 2005]

Vaughan Williams (2005) provides a comprehensive survey of efficiency in betting markets. Gandar, Dare, Brown and Zuber (1998) provide an introduction to the literature on insider trading in wagering markets; and recent thinking is summarized by Cain, Law and Peel (2001).

Historical studies of insider betting have pursued a variety of analytical strategies, with a recent trend towards quantifying its level.

Gabriel and Marsden (1990) compared bookmaker dividends and Tote dividends for the winners of UK thoroughbred races during the 1978 season, and found large, highly significant differences that persisted even after outliers were removed and across different periods. They argued that the dividends represent essentially identical financial claims and so should converge over time. Thus the gap is evidence that the market is not semi strong efficient (i.e. prices do not fully reflect all publicly available information), and perhaps is also subject to insider trading.

Another set of studies has tested for the presence of monopolistic information; this typically involves tipsters who are the most clearly identifiable group with potential insider knowledge. The general conclusion is that tipsters are able to match the accuracy and financial return of the wagering market (Vaughan Williams, 2000). This has proven true in thoroughbred wagering markets in the UK (Dowie, 1976), United States (Snyder, 1978) and Australia (Bird and McCrae, 1987).

An important group of studies has measured the extent of insider trading. For the 1973 UK flat racing season, Dowie (1976) examined changes in betting odds between those forecast the previous day and odds at the start of the race, and concluded that insider trading is not significant. Crafts (1985) took a similar, but more sophisticated, approach for a four-month period in 1982–3 and reversed Dowie's conclusion.

Shin (1993) examined 136 UK races in 1991 and found that bookmakers' margin is related to the number of runners, presumably because bookmakers use bigger fields to recoup losses to insiders. He developed a methodology to calculate insider activity and found that about two percent of bets were from insiders.

Schnytzer and Shilony (1995) made creative use of data taken from the pari-mutuel betting market in Melbourne to compare activities in parallel markets that would reveal availability of monopoly information. They generally found weak evidence of insider trading, and concluded it is declining.

Vaughan Williams and Paton (1997) examined the link between bookmakers' take and number of runners using high-grade handicaps, which have the greatest amount of media attention that should reduce the value of privately held information. They found that bookmakers' margin increases when the winning horses' odds shorten significantly during betting (implying greater insider activity), but decreases with high-grade races (implying less insider trading, although the latter is strongly correlated to the number of runners). They determined that insiders place about 2.1 percent of bets in lower grade races, but only a third as much in higher handicap races.

Cain, Law and Peel (2003) followed Shin's methodology to evaluate bookmaker betting markets in eight sports and found a level of insider trading between 1.9 and 7.8 percent of wagers. Coleman and McGrath (2005) analyzed pari-mutuel bets in Melbourne and estimated that up to ten percent of bets by value are from insiders. Fingleton and Waldron (2001) estimated that around four percent of betting in Ireland is by bettors with inside information.

Although there is an impressive literature on wagering market biases and efficiency, a significant limitation is its fragmented nature with many studies covering short time periods and only one of the pari-mutuel and bookmaker markets. Moreover, few studies develop cause-and-effect relationships surrounding wagering markets that enable rigorous tests of their efficiency.

3. DESCRIPTION OF MELBOURNE WAGERING MARKETS

Gambling on thoroughbred races is legal in Australia, and is principally conducted through on-course bookmakers and the pari-mutuel system, or totalisator ('Tote'). Since 1979, the Tote's share of the betting market has steadily risen from about 60 percent to above 85 percent (Tasmanian Gaming Commission, 2003).

Bookmakers offer fixed odds and compete for bets through an open outcry system; they pay a turnover tax. Bookmakers display the odds on a board, and alter them at their discretion in response to demand (bets placed) and supply (bookmakers' preferences and competitive factors). The first price that is displayed after the market reaches initial equilibrium is called Opening Price (OP); fluctuations in dividends are typically recorded on two or three subsequent occasions, with the last being the average bookmakers' dividend at the commencement of the race ('starting price', SP).

Bets with the Tote are placed electronically, by telephone, or by means of machine readable cards at Tote offices. To calculate dividends, the Tote deducts a fixed proportion of all bets to cover taxes and operating costs, and divides the balance between winning bets. The Tote has no control over the odds which change directly in response to investments during the betting period, and are continually displayed at its offices and on the Internet. Dividends are reported after the market has stabilized, and at three or four subsequent points in the betting: 15 minutes before the start, sometimes one minute before the start, at the start, and one minute after the start.

Effectively bets with a bookmaker are at a marginal price, whereas dividends paid by the Tote are an average; in practice the distinction is minimal as most bets are placed close to the start of the race[1].

Most races (almost 90 percent) in Melbourne are handicap events. The handicapper employed by the Racing Clubs evaluates the prospects of each horse, and – to give all runners an equal chance - assigns horses a minimum weight to be carried by the jockey. Each horse is then assigned a TAB number which starts at 1 for the highest weighted horse and so on down.

Because success in wagering is assumed to require skill, the racing industry supports a wide range of experts - 'tipsters' - who publish their forecasts of winners in newspapers and other media. They typically provide three horses in predicted finishing order, sometimes with a selection of best bet(s). A difficulty in using tipster forecasts is that their motivations are unstated, so it is only assumed they unconditionally seek to maximize the accuracy of their tips, and not (say) choose 'value' horses. In addition, it is hard to quantify tipsters' credentials and intellectual input; so differences in their inherent skill cannot be quantified.

Because tipsters finalize their predictions at least 12–24 hours before any meaningful market is formed, they rely solely on their individual skill (and specialist knowledge) and so are a measure of the value of information other than that contained in the wagering market. Thus an independent estimate of a horse's probability of winning can be derived from tipster forecasts.

3.1 Quantifying Wagering Markets

The following analysis uses the definitions and nomenclature which have usually been followed since first established by Griffith (1949) and Ali (1977).

Consider there are n horses in a race, which are numbered in decreasing order of favoritism as 1,2... h...n. Let X_h be the amount bet for a win on horse h. In a pari-mutuel market, a proportion of the pool equal to α is taken out by the Tote to cover taxes and operating costs. Thus the win dividend paid by the Tote on any horse is:

$$(1) \qquad D_h = \frac{(1-\alpha)\sum_{h=1}^{n} X_h}{X_h}$$

The subjective probability that any horse will win, p_h, is established by bettor preferences and is equal to the proportion of the pool that is bet on any horse:

$$(2) \qquad p_h = \frac{X_h}{\sum_{h=1}^{n} X_h} = \frac{1-\alpha}{a_h + 1}$$

where a_h is the win odds on any horse, and equals $(D_h - 1):1$.

This value of p_h needs adjusting because dividends in Melbourne are rounded down to the nearest ten cents (rounding down occurs in virtually all pari-mutuel markets, and can be as high as to the nearest 20 cents). Thus reported dividends will on average be five cents less than the exact dividend. In the calculations below, five cents has been added to the reported dividend before calculation of p_h.

The objective probability that any horse will win, π_h, is not directly observable. Most studies calculate it as the proportion of times a horse starting at any particular odds has historically won. This is determined by grouping starters according to win dividend and then dividing the number of winners in each group by the total runners.

Using simple math, the expressions above can be used to develop a measure of insider activity in the Tote market. Assume a wagering market which is efficient and has no bias: p_h equals π_h, so that market odds accurately reflect each horse's objective probability of winning; and the expected return at all odds is the same (and equal to the operator's negative take). Now consider that insiders (who possess information not available to other bettors) become involved. Let the amount they wager equal i proportion of the bets by 'outsiders', and assume that it is invested exclusively on the winner. If D_w^* is the dividend on the winner in a market where insiders operate:

$$D_w^* = \frac{\text{Net Amount Bet on the Race}}{\text{Amount bet on winning horse w}}$$

$$= \frac{(1-\alpha)^*(\text{Total Bets of 'Outsiders'})^*(1+i)}{(p_w+i)^*(\text{Total Bets of 'Outsiders'})}$$

$$= \frac{(1-\alpha)^*(1+i)}{(p_w+i)} \tag{3}$$

$$\text{From above}: D_w^* = \frac{(1-\alpha)}{\pi_w}$$

$$\text{Therefore for any one race, x}: \quad i_x = \frac{\pi_w - p_w}{1-\pi_w} \tag{4}$$

where p_w and π_w relate to the winner.

The relationship shown in equation (4) is the classic longshot bias where the objective probability of a win by a short priced horse is greater than its subjective probability (and the subjective probability of a longshot's win is less than its objective probability). The strength of the longshot bias is a measure of insider betting, which implies the logical behavior that knowledgeable bettors are more likely to bet on favorites[2].

A more complicated approach that can be applied to bookmaker markets with qualitatively similar results was developed by Shin (1993) and has since been used by Cain, Law and Peel (2001), Paton, Vaughan Williams and Fraser (1999), and others. It assumes that bookmakers protect against potentially large losses by requiring a risk premium that is proportional to odds; moreover they take a higher margin in races with more runners to recoup their losses to insiders. This enables calculation of parameter, z, which is a measure of insider trading.

The calculation is briefly described as follows. Assume investors buy a betting ticket that is a state contingent claim which pays the odds for a win and nothing otherwise. For odds of k-to-l, the price of one unit of this claim, π_i, is equal to l/(k + l); or 1/(Odds + 1). If n is the number of runners in the race, to be certain of obtaining one unit of payout, a bettor must buy n tickets for a total cost of $\beta = \sum_{i=1}^{n} \pi_i$; $\beta - 1$ is the bookmaker's take or margin on the race and should be positive. The normalized value of π_i, $\tilde{\pi}_i$, is equal to π_i;/β. The objective probability that the horse will win, p_i, is not observable.

Following Cain, et al. (2001), the calculation of z for each race goes through a number of iterative steps:

Select an initial estimate of z and make a first estimate of p_i:

$$(5) \qquad p_i = \left[\frac{z^2}{4^*(1-z)^2} + \frac{\pi_\iota^2}{\beta^*(1-z)}\right]^{0.5} - \left[\frac{z}{2^*(1-z)}\right]$$

Obtain a revised estimate of z by substituting the estimate of p_i into the following equation:

$$(6) \qquad z = \left(1 - \sum_{i=1}^{n} p_i^2\right)^{-1} \left(\beta^* \sum_{i=1}^{n} \tilde{\pi}_i^2 - \sum_{i=1}^{n} p_i^2\right)$$

Repeat the process until $\sum_{i=1}^{n} p_i = 1$ and z converges[3].

3.2 Analytical Strategy and Hypotheses

A number of assumptions have shaped the analytical approach of this study.

The first assumption is that insiders have access to more knowledge than even the most skilled outsider. Thus, for instance, insiders will be more accurate judges of a horse's ability than the handicapper and racing experts.

The handicapper's objective is for all horses to finish together. Assuming this objective is met, horses with different weights (and hence TAB numbers) will have equal probability of winning: thus the median of winners' TAB numbers should be the median of all runners' TAB numbers. If, however, information about a winner's ability is not generally available (but withheld by insiders), winners will have a greater probability of success than expected by the handicapper. Thus their handicap weight will be set too low, and winners will have a higher TAB number than the median. This leads to the hypothesis that the presence of insiders will be signaled by a median TAB number of the winners of handicap races which is greater than the median for all runners. Any increase in insider trading will lift winners' TAB number.

Although tipsters' forecasts are independent of the market, they are about as accurate and so provide a measure of runners' objective probability of winning. This can be modeled using an expression such as:

$$(7) \qquad \text{E(market)} = \text{a} + \text{b.E(tipster)} + \varepsilon$$

where E(market) and E(tipster) are the probabilities of winning established by wagering market prices and tipster predictions, respectively, and a and b are constants[4].

Assume that tipsters' forecast of the performance of any horse is calculated following past practice (e.g. Bird and McCrae, 1987) by giving three points if the horse is chosen to win, two points for second and one for prediction of third place. Tipster probabilities are indicated by the weighted

tips divided by the theoretical maximum support (which in this study is 78 because it reports forecasts of 13 tipsters who each have 3 + 2 + 1 points per race). The values of a and b in equation (7) can be derived by regressing market probabilities of a win calculated as per equation (2) against those from tipster predictions.

If insiders successfully use information that is not generally available, horses are more likely to win than expected by the market and experts. Should insider trading increase, successful bets by insiders will reduce winners' dividends relative to the probability established by tipsters (at least those without the inside information) and this will be evidenced by a fall in b, and a reduction in the explanatory power (i.e. adjusted R^2) of equation (7).

Extending the discussion above, if each horse has an equal chance of winning, the average dividend of winners of handicap races should be equal to (1 − Bookmaker or Tote Take)*Field Size. A lower dividend signals insider knowledge; and an increase in insider trading will see the average winner dividend fall.

Another assumption is that most insider bettors will prefer to bet close to the start of the race. This is to allow the market to approach equilibrium, and also to preserve their options to take a higher price. For insiders who bet on the Tote (where all bettors receive the same odds), a further incentive to delay bets is to avoid signaling superior knowledge to less informed bettors.

The pattern of bets will set up biases in the movement of odds. In a fully efficient market with no constraints to either the supply or demand sides, changes in prices should be random rises and falls. The Tote market, however, is a closed system and this introduces an upwards bias into dividend fluctuations. At the extreme, for instance, each bet leads to fall in one runner's dividend and a rise in all other runners' dividends. Thus there will tend to be more up than down moves in Tote dividends.

A somewhat different dynamic will apply in bookmaker markets because they also have considerable supply-side influences as bookmakers manually adjust prices in light of bets and competitor activity. Thus bookmakers tend to initially post conservative odds to avoid possible adverse selection and raise them through the betting session as demand for individual horses becomes clear and competition reduces margins[5].

In both the bookmaker and Tote markets, insider trades will be delayed, and will be signaled by a greater proportion of falls in winners' odds than in all runners' odds.

Moreover, bookmakers themselves can undertake insider trading by reducing the odds they offer for a horse they think is likely to win and *vice versa*. This would be evidenced by bookmaker dividends on winners that are lower than on the Tote. An increase in insider trading would be evidenced by an increase in the gap between bookmaker dividends on winners and those paid by the Tote.

These assumptions point to 13 hypotheses that would signal the existence and change in insider trading. Insider trading will be indicated by:

H1a The proportion of downwards moves in the final fluctuation of winners' dividends on the Tote is greater than the proportion of downwards moves for all runners

H1b The proportion of downwards moves in the final fluctuation of winners' dividends with bookmakers is greater than the proportion of downwards moves for all runners

H2 TAB numbers of the winners of handicap races are higher than the median of all runners

H3a Win dividends on the Tote for winners of handicap races are lower than the value of (1 − Tote Take)∗Field Size.

H3b Win dividends with bookmakers for winners of handicap races are lower than the value of (1 − Bookmaker Take)∗Field Size.

H4 The value of z per Shin's methodology is greater than zero

Further hypotheses are that an increase in the extent of insider trading will be indicated by:

H5 An increase in the proportion of downwards moves in the final fluctuation of winners' odds with bookmakers (and the Tote)

H6 An increase in the TAB number of the winners of handicap races

H7a A decrease in the dividend on the Tote for winners of handicap races.

H7b A decrease in the dividend paid by bookmakers for winners of handicap races.

H8 An increase in the value of TAB Dividend minus Bookmaker Dividend

H9 Reduced explanatory power of tipsters' predictions

H10 The value of z per Shin's methodology will increase

Let us now discuss the data used to test these hypotheses before turning to the results.

3.3 Data for this Study

The study is conducted using results for thoroughbred race meetings in Melbourne, which is a city of three million people that is located in south-eastern Australia. It supports four metropolitan racetracks with a thoroughbred horseracing program at one track each Saturday and usually on one other day during the week. In Melbourne the tote is run by TABCORP Holdings Limited (hereafter Tabcorp), which is a listed public company that provides gambling at casinos and other venues including sports betting offices on and off-course.

Analysis was confined to Saturday meetings as tipster predictions are not available on other days. Data were compiled for a total of 3,540 races during the period January 1996 to June 2004, and came from four sources. The first was a commercial service, Southcoast Database, which provided field data

including: date of the meeting, and name of the venue; the number of the race and its classification (class and whether it is a handicap); and the following information for all runners: the name of each starter and its TAB number, finishing position, bookmaker starting price and fluctuations in dividends prior to the start. Tabcorp win dividends for all runners after January 2000 were obtained from Thoroughbred Racing Bureau [www.trb.com.au]; and fluctuations in Tabcorp dividends of all runners after October 2002 were provided by another commercial researcher, Mr. Martin McGrath [www.raceguides.com.au].

The fourth source involved hand collection of data. These comprised the TAB win dividend for the winner of each race between 1996 and 2000 from the Sunday edition of *The Age* (a Melbourne daily newspaper); and the predictions of placegetters in each race between 1996 and 2004 that were made by 13 tipsters published in the Saturday editions of *The Age* and *The Australian* (a national newspaper published in Sydney) which, respectively, publish six and seven tipsters (one in *The Australian* is a computer based expert system called Computercard)[6].

Data on winners, tipsters and bookmaker markets were available for the period January 1996 to June 2004; however, Tote dividends for horses that did not win were only available after January 2000, and fluctuations only since 2002[7]. Thus the analysis has been divided into two roughly equal periods – January 1996 to December 1999, and January 2000 to June 2004 – for evaluation of changes over time and to enable comparability of bookmaker and Tote data during the second period.

4. EMPIRICAL RESULTS

The analysis tested the hypothesized measures of insider trading, and the principal findings shown in Table 1 provide statistically significant ($p < 0.05$) support for nine of the 13 hypotheses. There is convincing evidence that insiders are active in the Melbourne wagering market, and their level of their activity has grown over the last decade.

4.1 Existence of Insider Activity

Hypotheses 1a and 1b are that insiders bet late (to keep their options open and prevent herding by outsiders) and thus the proportion of downwards fluctuations in the final move of winners' dividends in the Tote and bookmaker markets will be higher than for other runners. Hypothesis 5 is that greater insider activity will be signaled by an increase in the proportion of downwards final moves in bookmaker odds.

As shown in Table 2 bookmaker markets display strong ($p < 0.001$) evidence of insider trading: whilst only 28 percent of the final fluctuations for all runners were down, 44 percent of winners' final fluctuations were down. This proportion dropped slightly during the period, although not with statistical significance ($p > 0.3$).

TABLE 1
SUMMARY OF STUDY FINDINGS

This table lists the 13 hypotheses developed in the paper which – as shown in panel A - evidence the existence of insider trading in Melbourne thoroughbred wagering markets, and – as shown in panel B – evidence an increase in insider trading. The results of analysis are reported in the far right column as indicative of support or not for the existence of, and increase in, insider activity. Levels of confidence are shown, with *** indicating 99 percent confidence, ** indicating 95 percent, and * indicating 90 percent confidence.

Hypothesis	Win Market Measure	Indication of insider trading	Supports Insiders?
Panel A: Evidence of the Existence of Insider Trading			
1a	Proportion of downwards moves in the final fluctuation of winners' Tabcorp odds	Greater than mean for all runners	Yes***
1b	Proportion of downwards moves in the final fluctuation of winners' bookmaker odds	Greater than mean for all runners	Yes***
2	Median TAB number of winners of handicap races	Higher than median of all runners	No***
3a	Tabcorp dividend of winners of handicap races	Less than (1 − Tabcorp Take)*Field Size	Yes**
3b	Bookmaker dividend of winners of handicap races	Less than (1 − Bookmakers' Take)*Field Size	Yes***
4	The value of Shin's z	Greater than zero	Yes**
Panel B: Evidence of an Increase in the Level of Insider Trading			
5	Proportion of downwards moves in the final fluctuation of winners' bookmaker odds	Increase	Yes
6	Median TAB number of the winners of handicap races	Increase	Yes**
7a	Dividend on Tabcorp of winners in handicap races	Decrease	Yes
7b	Dividend with bookmakers of winners in handicap races	Decrease	Yes**
8	Value of TAB Dividend minus Bookmaker Dividend	Increase	Yes***
9	Ability of tipsters to pick winners	Explanatory power falls	Yes**
10	The value of Shin's z	Increase	Yes

TABLE 2
PROPORTION OF DOWNWARDS MOVES IN THE FINAL FLUCTUATION OF WINNERS' DIVIDENDS

This table reports results for tests of Hypotheses 1a and 1b, and 5. Insider trading is evidenced by a higher than expected proportion of downwards moves in the final fluctuation of winners dividend; and the proportion would rise in line with the level of insider activity. Dividends are recorded at up to four stages in the betting, and this table reports mean values of the final fluctuation in winners' dividends before betting stops. For both Tote and bookmaker markets, if there were no manipulation the pattern of winners' final fluctuations will be the same as that for all runners. In each case the last fluctuation is assumed to be a binomial rise-or-fall distribution whose standard deviation is given by $\sqrt{[\text{mean}*(1 - \text{mean})/(\text{sample size})]}$

	Tote (Tabcorp)	Bookmakers
Null Hypothesis Value: mean for all runners	36.6	27.8
January 1996 to December 1999 (3540 races)	[data not available]	44.4
January 2000 to June 2004	[data not available]	43.6
October 2002 to August 2004 (799 races)	45.9	
Full Sample Period		
Mean	45.9	44.0
Sample standard deviation	1.70	0.75
t-statistic	5.5	31.4
Significance	0.001	0.001

Results for Tabcorp betting show a similar pattern: although 36.6 percent of all runners' final dividend moves were down, the figure was 45.9 percent for winners, which is also highly significant ($p < 0.001$).

Hypotheses 2 and 6 are that handicaps ensure runners finish together so that the median of TAB numbers for winners should be the same as that for all runners. Under hypothesis 2, insider trading will be evidenced by the winners' median TAB number above the median for all runners; and hypothesis 6 expects an increase in winners' TAB numbers if insider activity strengthens.

Table 3 conclusively rejects hypothesis 2: the median TAB number for winners is 5.0, which is significantly ($p < 0.001$) below the 7.1 for all runners; thus horses perform better than expected by the handicapper. This is clearly not supportive of insider trading. However, it is consistent with a conservative bias by the handicapper who underweights promising runners.

Conversely the table shows a significant ($p < 0.05$) increase in winners' TAB number across the two sub-periods and hence confirms hypothesis 6 (assuming the apparent handicapper bias is constant).

The next set of hypotheses to be tested also assumes that – in the absence of insider trading - each runner has an equal probability of winning. Hypotheses 3a and 3b are that the expected dividend is the value of one minus operator's take multiplied by the average number of starters in each race. The takes for Tabcorp and bookmakers are 16.9 and 20.0 percent, respectively[8]; and there is an average of 11.0 runners in each race. Thus – in the absence of any bias - the expected win dividends are $9.1 with Tabcorp and $8.8 with bookmakers.

TABLE 3
TAB NUMBERS OF WINNERS

This table reports results for tests of Hypotheses 2 and 6 which are based on the assumption that handicaps ensure runners finish together. Thus the median of TAB numbers (which are based on descending order of weight handicap) for winners should be the same as the median for all runners. Hypothesis 2 assumes insider trading will be evidenced by winner TAB number above the median for all runners, and hypothesis 6 expects an increase in the gap if insider activity strengthens.

	Median TAB Number of:	
	Winners (N = 3,442)	All Runners (Null hypothesis value)
January 1996 to December 1999	4.93	7.08
January 2000 to June 2004	5.07	7.00
January 1996 to June 2004		
Median value	5.00	7.06
Population standard deviation		4.13
Sample standard deviation	0.071	
Actual – Null hypothesis value	2.06	
t-statistic	29.3	
Significance	0.001	

Table 4 supports hypotheses 3a and 3b with win dividends significantly ($p < 0.05$) lower than expected for both Tabcorp and bookmakers at $8.8 and 8.1, respectively. The data also support hypothesis 7b with a significant ($p < 0.005$) fall in bookmaker win dividends. Although the fall in Tabcorp odds during the study period is consistent with hypothesis 7a, it is not significant ($p > 0.3$).

The data also strongly support ($p < 0.001$) hypothesis 8 that an increase in insider trading will reduce bookmaker odds relative to Tabcorp odds.

Hypothesis 9 is based on the assumption that the probability of winning as assessed by Tote and bookmaker markets will have a consistent relationship with the probability of winning as assessed by tipsters. Any increase in insider activity will reduce the value of publicly available information; this, in turn, will see markets give a higher probability of winning relative to tipsters, and reduce the explanatory ability of tipsters. Table 5 shows that tipsters' predictive power has declined: win probabilities in both wagering markets rose significantly ($p < 0.001$) relative to the probability of winning predicted by tipsters. This strongly supports hypothesis 9.

4.2 Quantification of Insider Activity

The longshot bias (or tendency for the expected return to be proportional to outcome probability) in the Tote market is - as per equation (3) - a measure

TABLE 4
DIVIDENDS PAID ON WINNERS

This table reports results for tests of Hypotheses 3a and 3b, and 7a and 7b. The assumption is that handicaps ensure that each runner has an equal probability of winning and hence the expected dividend is the proportion paid from the pool (i.e. one minus operator's take) multiplied by the average number of starters in each race. The takes for Tabcorp and bookmakers are 16.9 and 20.0 percent, respectively; and there is an average of 11.0 runners in each race (11.2 in 1996–2000, and 10.9 in 2000–2004). Hypotheses 3 a and b are that – in the absence of any bias - the expected win dividends are $9.14 on Tabcorp and $8.80 with bookmakers. Lower values indicate insider activity. Hypotheses 7 a and b are that the dividends decrease if insider activity increases.

	Tabcorp	Bookmakers	Tabcorp − Bookmaker
Null Hypothesis value	9.14	8.80	0.34
January 1996 to December 1999	8.88	8.25	0.63
January 2000 to June 2004	8.75	7.88	0.84
t-statistic	0.53	2.18	2.40
Significance	0.60	0.03	0.02
January 1996 to June 2004			
Mean	8.81	8.06	0.74
Population standard deviation	9.95	7.18	3.72
Sample standard deviation	0.170	0.122	0.063
Actual – Null Hypothesis Value	−0.33	0.74	0.40
t-statistic	1.9	6.1	6.3
Significance	0.05	0.001	0.001

of insider betting. Table 6 reports a pronounced longshot bias, and applying equation (4) to the dataset shows that insiders place 1.9 percent of wagers on winners that pay a dividend of less than $5, and about 0.4 percent of all bets.

Table 7 reports estimates of insider trading in bookmaker wagering markets, z, using the methodology proposed by Shin (1993); and also shows results from regression of z against various race traits as independent variables.

Panel B reports the extent of insider trading: the value of z was 2.3 percent in 1996–1999, and 2.1 percent in 2000–2004. The mean across the whole period of about 2.2 percent is not significantly different to values for English racing in 1978 and 1987 reported by Cain, et al. (2003) of 2.7 to 3.3 percent; and in 1991 by Shin (1993) of 2.0 to 2.6 percent.

Panel C explains the contributors to insider trading in bookmaker markets by reporting results of linear regression using z as the dependent variable, and race date, number of runners, TAB number, bookmaker SP, β and race stake money as the independent variables (the last three are generally seen as influencing z). Almost 90 percent of the variation in z is explained by three highly significant ($p < 0.02$) variables: number of runners in the race, beta and race stake money.

4.3 Alternative Explanations

Although the results above are strongly – and consistently – indicative of the existence of insider bettors and an increase in their activity, it is not

TABLE 5
PERFORMANCE OF TIPSTERS

Hypothesis 9 is based on the assumption that an increase in insider activity will reduce the explanatory ability of tipsters. It uses the expression: E(market) = Intercept + Slope*E(Tipster) +ε, where: E(market) and E(Tipster) are the probabilities that any horse will win based on wagering market odds and tipster predictions; E(market) is calculated as Dividend/(1 − Tabcorp or bookmaker take); and E(Tipster) is the weighted value of tips for each winner (with 3 for a win, 2 for 2nd and 1 for 3rd) divided by the theoretical maximum tipster support of 78. An increase in insider activity will reduce the value of publicly available information and reduce the explanatory ability of tipsters: thus R^2 should fall and Slope should rise. Panel A of this table reports results for Tabcorp, and those for bookmakers are shown in panel B.

	Intercept	Slope	Adjusted R^2
Panel A: Tabcorp Odds			
January 1996 to December 1999	0.061	0.541	0.372
January 2000 to June 2004	0.069	0.633	0.320
January 1996 to June 2004	0.069	0.566	0.330
Standard error		0.0136	
Change from 1996–99 to 2000–4		0.092	
t-statistic		6.8	
Significance		0.001	
Panel B: Bookmaker Odds			
January 1996 to December 1999	0.063	0.464	0.369
January 2000 to June 2004	0.0724	0.533	0.316
January 1996 to June 2004	0.070	0.481	0.328
Standard error		0.0112	
Change from 1996–99 to 2000–4		0.069	
t-statistic		6.2	
Significance		0.001	

possible to exclude other explanations. Two obvious examples are changes in publicly available information and in reliability of horses' performance.

In the first case, there could have been a decrease during the last decade in the amount of information that is publicly available about horses' prospects. As a result, insider information would comprise a larger – and hence more valuable – component of the information about any horse's prospects of winning. Such a development is hard to accept given the data that has emerged from better technology (such as cable television broadcasts and computer analysis of races) and more intense coverage by a wider range of analysts and media. It is also inconsistent with what appears to be greater energy by the stewards to improve transparency.

Similarly there could have been a systematic decrease in the reliability of horses' performance due (say) to changes in breeding, training or field quality. If horses were less likely to run according to their historical form, insider information becomes more valuable and the predictive ability of publicly available information would fall. Exactly this, of course, is shown in Table 5

TABLE 6
LONGSHOT BIAS IN TOTE MARKET AND LEVEL OF INSIDER TRADING ACTIVITY

The table below uses data from the Tote market during 2000–2004 to reveal the strength of the longshot bias, or tendency for expected return to be inversely proportional to outcome probability. This data is then used to derive an estimate of the Objective Probability of Winning as a function of Dividend.

Dividend range − $	Runners	Winners	Objective Win Probability	Average Dividend of Winners	Subjective Win Probability	Expected return (%)
<1.5	36	25	0.694	1.40	0.583	(2.78)
1.6–2.6	439	167	0.380	2.19	0.377	(16.61)
2.7–3.7	990	274	0.277	3.20	0.260	(11.34)
3.8–4.6	1033	225	0.218	4.20	0.199	(8.59)
4.7–6.3	2044	327	0.160	5.45	0.154	(12.78)
6.4–8.0	1925	225	0.117	7.11	0.118	(16.91)
8.1–10.2	2057	199	0.097	9.09	0.092	(12.11)
10.3–12.5	1804	153	0.085	11.30	0.074	(4.16)
12.6–16.5	2117	110	0.052	14.27	0.059	(25.84)
16.6–23.9	2386	90	0.038	19.48	0.043	(26.52)
24–39.9	2546	78	0.031	30.31	0.028	(7.14)
40–435	3241	31	0.010	59.56	0.014	(43.03)
TOTAL	20618	1,904	0.092	8.76	0.096	(19.12)
Memo: $5 or less	3006	778	0.259	3.40	0.245	(11.96)

Regression of Objective Probability of Winning against Dividend:
Objective Probability, $\pi = 0.9371 * Dividend^{-1.0378}$ [Adjusted $R^2 = 0.996$]

as a decline in tipsters' accuracy and in Table 3 as a decline in handicappers' efficiency. Thus it is not possible to reject declining reliability as an explanation of these results. However, it seems improbable, in particular because of the growing economic importance of the horse racing industry in Australia (Gordon, 2001).

In summary the data provide statistically significant support for nine of the 13 hypotheses; directionally support a further three hypotheses; and reject one hypothesis. Let us discuss the implications of these findings in the following section.

5. DISCUSSION AND IMPLICATIONS

The key research questions of this paper are: is there conclusive evidence of insider trading in thoroughbred wagering markets? And has the level changed through the last decade? Satisfactory answers to both questions can be found in the data reported in the previous section. This provided statistically significant ($p < 0.05$) confirmation of five of the six hypotheses relating to the existence of insider trading and four of the seven hypotheses relating to an increase in insider trading.

TABLE 7
SHIN ESTIMATES OF INSIDER ACTIVITY IN BOOKMAKER MARKET

This table reports the results from analysis of bookmaker wagering markets using the Shin (1993) methodology. For bookmaker odds of k-to-l, the market-based probability that any runner, i, will win, π_i, is equal to l/(k + l); with n runners in the race, the value of beta is $\beta = \sum_{i=1}^{n} \pi_i$; and the bookmakers' margin equals beta minus 1. The proportion of bets by insiders is z.

Panel A: Operator's Margin

	Mean	Standard Deviation	Maximum	Minimum
January 1996 to December 1999 (n = 1762)	0.215	0.149	1.593	0.0029
January 2000 to June 2004 (n = 1681)	0.193	0.057	0.488	0.0035
January 1996 to June 2004 (n = 3446)	0.204	0.140	1.593	0.0029

Panel B: Extent of Insider Trading, z (percent)

	Mean	Standard Deviation	Maximum	Minimum
January 1996 to December 1999	2.28	1.04	11.4	0.002
January 2000 to June 2004	2.10	0.69	5.3	0.004
January 1996 to June 2004	2.19	0.89	11.4	0.002

Panel C: Regression of z Against Race Parameters

	Constant	Runners (#)	Beta	Stake ($ million)	Adjusted R^2
January 1996 to December 1999	−0.0855	−0.0021 (92.4)	0.1093 (97.5)	0.0025 (5.97)	0.886
January 2000 to June 2004	−0.0500	−0.0020 (64.6)	0.0782 (125.0)	0.00075 (1.81)	0.895
January 1996 to June 2004	−0.0538	−0.0020 (96.5)	0.0813 (156.8)	0.0012 (3.82)	0.880

Wagering markets clearly show biases that are to be expected from the existence of appreciable levels of insider trading. For instance, in both the bookmaker and Tote markets, there is a much higher proportion of downwards moves in the final fluctuation of a winning horse's dividend than in the final fluctuation of all runners' dividends (which evidences a disproportionate late flow of informed investments).

Over time the biases predicted from insider trading have strengthened. The proportion of downwards moves in final fluctuations rose; and the predictive power of tipsters and the handicapper fell. Dividends paid for a win by bookmakers and Tote both dropped, and by a greater proportion in the bookmaker market.

An important change has been the decline in the value of publicly available information. The implication of this result for outsiders is demonstrated by reference to a typical high probability runner which eight out of 13 tipsters predict to win. In the period 1996 to 2000, this would pay a dividend of around $3.7 on the Tote and $3.9 with bookmakers. In the second period, however, the same level of tipster support results in dividends of $3.2 and 3.4, respectively. In the first period, the betting markets assign a probability of winning of about 23 percent to a horse that eight tipsters have picked to win; in the second period the probability is around 27 percent. Thus the expected return at this particular level of skill has fallen by about one sixth over eight years. In other words, the return from a given quantum of publicly available information has fallen: private information that is not impounded in tipster predictions has become more valuable.

The extent of insider trading was quantified in the bookmaker and Tote markets using different methodologies. This showed that insiders place 2.2 percent of bets in the bookmaker market, and 0.4 percent in the (much larger) Tote market.

Insider trading has been a roughly constant share of the (declining) bookmaker market since the mid 1990s. The extent of insider activity is highest in races with small fields and large stakes which contradicts results from studies in the UK (Vaughan Williams and Paton, 1997).

Although the estimate that around two percent of bets are placed by insiders might appear small, it is consistent with the findings of a number of other studies including Cain, et al. (2001), Shin (1993), Terrell (1997) and Vaughan Williams and Paton (1997). Moreover it is important to note that tests in a number of settings have shown that a relatively small volume of informed investments can move markets. For instance, Lopes (1994) reports evidence from the University of Iowa's Presidential Stock Market that a small group of marginal traders influenced the market price. This, of course, is how markets produce relatively unbiased estimates, even in the presence of many uninformed investors.

The data point to a number of changes that have taken place in the wagering market in parallel with increased insider activity. One of the most important is shown in Table 8: short-priced horses have a growing probability

of winning. In the early years of the study horses starting at a bookmaker win dividend of $3 or less won 13.7 percent of races; they now win 15.0 percent of races. This result is consistent with increased insider trading (more money is placed on winning horses) which results in lower dividends offered by bookmakers. Moreover, the expected return from betting with bookmakers at all dividend levels has fallen by about three percent. This does not seem to be due to an increase in the bookmakers' margin which – as per Table 7 - stayed roughly constant.

To answer the question posed in the title of this paper, my results confirm other data that around two percent of wagering investments are by insiders; and empirical measures of insider trading show that it has increased significantly in the last decade. There is little doubt that insider trading is a serious and growing issue in the thoroughbred wagering market.

Because the wagering market appears to be competitive, efficient and well-regulated, the level of insider activity identified in this study is likely to be qualitatively similar to that in conventional financial markets. Although no study has quantified insider activity in equity markets, the papers discussed in section I found that insiders make between a third and half of stock trades when monopoly information is valuable to investors. This is not inconsistent with the implication that several percent of *all* trades involve insiders.

Leaving aside considerations of ethics and equity, the presence of even a small proportion of insiders has serious financial implications for outsider investors. Consider high probability runners in a wagering market that start at a win dividend of $5 or less. As shown in Table 6, the Tote market gives them a 0.245 subjective probability of winning, which means that 24.5 percent of wagers are on these runners; they have an expected return of -12 percent. Assume that i percent of wagers are placed by insiders on the winners at an average dividend of $3.4; the return to insiders is 240 percent (i.e. a net return of $3.4 minus the $1 bet). Winners paying $5 or less attract 24.5 percent of all bets; insiders comprise i percent of bets and earn 240 percent; outsiders make 24.5–i percent of bets; and the average return is -12 percent. Thus:

$$\text{Return to all bettors} = [i^{*}240 + (24.5 - i)^{*}(\text{Return to Outsiders})]/24.5 = -12.$$

$$\text{Therefore: Return to Outsiders} = -(294 + 240i)/(24.5 - i).$$

In a strongly efficient market where $i = 0$, outsider bettors could expect a return of minus 12 percent from backing horses starting at $5 or less. However, when insiders make just one percent of bets on the winners, the return to outsiders falls to minus 23 percent (and goes to minus 47 percent where insiders make three percent of successful bets).

If insiders are also responsible for several percent of trades in other markets, there will be a similarly significant fall in returns to outsider investors. This should strengthen the resolve of regulators to stamp out unscrupulous operators in every market.

The conclusion that insiders remain active in financial markets and can enjoy substantial monopoly profits should not be a surprise. For instance, a common investment strategy has been to follow the lead of officers who disclose trades in their companies as these provide significant excess returns. In a typical study, Seyhun (1986) analyzed a large volume of trades by corporate officers in the United States in the late 1970s and found an outperformance of up to about seven percent per year. He estimated (page 201) that these publicly disclosed trades by corporate officers comprise between 0.8 and 4.0 percent of all trades, and the proportion is inversely related to firm size. Friederich, Gregory, John and Tonks (2002) reached a similar conclusion in the United Kingdom.

An interesting question which is raised by this study is the extent to which insider trading would set up quantifiable biases in other markets. As discussed earlier, insider trading is a sufficient explanation for the longshot bias in wagering markets. What impact would insider trading have on equities markets? And on other markets? Students of behavioral finance may advance their discipline by developing additional hypotheses that evidence such impacts and test for their existence.

Despite the large dataset used here and considerable effort expended in its evaluation, a number of areas remain for further research. First, the analysis could be extended along lines proposed by Law and Peel (2001) to distinguish herd behavior from insider trading, possibly by considering the nature of plunges. Another extension following Vaughan Williams and Paton (1998) is to separately analyze higher quality races with qualitatively superior public information to see if insider activity is diminished. Finally it would be interesting to replicate this analysis in other markets where data are available (e.g. Hong Kong, New Zealand, UK and USA) to compare international experience of the extent and changes in insider trading.

TABLE 8
OBJECTIVE PROBABILITIES OF WINNING

Panel A shows the objective probability that a horse within a particular range of bookmaker odds will win. This is calculated by dividing all runners according to the range of odds, and calculating the proportion of winners (i.e. winners*100/runners) within each range. Panel B shows the percentage of all winners falling within each odds range.

	Bookmakers' Win Dividend - $			
	≤ 2.0	2.1–3.0	3.1–9.9	≥ 10
Panel A: Objective Probability of Winning by Dividend – percent				
1996–2000	47.2	33.7	15.0	3.8
2000–2004	64.4	37.4	15.3	3.8
Panel B: Percent of Winners				
1996–2000	2.9	10.8	60.5	25.8
2000–2004	3.1	11.1	60.8	25.0

NOTES

1. Based on several samples during 2003–4, my estimate of the proportions of the final Tote pool which are wagered at 15 minutes before the start, five minutes before the start and one minute before the start (which is the last time odds are reported before betting is closed) are 30, 60 and 80 percent, respectively. This was confirmed by the Melbourne pari-mutuel operator, Tabcorp, who responded [personal communication, 15 September 2004] to my e-mail enquiry: "the investment percentages you are quoting (30–60%) would generally occur within the last 2–3 minutes [before the start of the race]."
2. There are other possible explanations for the longshot bias such as bettors' over-estimation of the probability of occurrence of low frequency events, or their assumption of an equal risk-weighted return from wagering and preference for the small chance of a large win (Coleman, 2004). Moreover some of the bias may be caused by herd behaviour, rather than true insiders; and some insider bets may not go to the winner. The assumption that insiders are the sole cause of the longshot bias makes the resulting estimate of insider activity a maximum.
3. The analysis in this paper was performed using Excel: races where $\beta < 1$ were eliminated; then data for each race were first grouped by number of runners, and values were calculated for π_i, $\tilde{\pi}_i$, and β; the goalseek function was used to vary z so that $\sum_{i=1}^{n} p_i = 1$.
4. Alternatively historical data for all runners can be used to establish a probability of winning based on tipsters' predictions. Thus E(market) and E(tipster) can be treated as independent estimates of each winner's probability of success, and values of RMSE for each pair can be calculated and compared between periods. If insider activity had altered, RMSE should change, too.
5. However, note that Gabriel and Marsden (1990: 878) state – without any amplification – "we would expect [bettors with inside information] to place early fixed odds bets with bookmakers".
6. In addition, of course, there are at least as many tipsters available from private tipping services (provided by fax or e-mail), 'late mail', newswire services (particularly Australian Associated Press) and specialist publications (such as *Best Bets and The Sportsman*). Fortunately, several newspaper tipsters are syndicated from other media, so there is some crossover.
7. Although Tabcorp operations are computerised, it does not retain (or at least will not provide researchers with) electronic files of race results. These are only available race by race on its website [www.tabracing.com.au] after August 2002.
8. These are my calculations using data in this analysis. According to Tabcorp [www.tab.com.au/cms/betrules/Parimutuel_BetRules.pdf] the "return to investor" (which is not defined) in Victoria in recent years has varied between 14.5 and 16 percent. Tasmanian Gaming Commission (2003) assumes a bookmaker take of five percent, but does not provide any justification.

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